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ABSTRACT

Reductions in the funding of compensatory education along with observed discrepancies in per-pupil cost among equally effective schools created a compelling case for the study of the determinants of cost-effective Chapter 1 programs in the state of Minnesota. Cost-effectiveness (CE) indexes for Chapter 1 reading and math services reflected a ratio between a district's weighted mean normal curve equivalent gain and the average per-pupil cost. A random sample of 141 Chapter 1 programs participated in the study with a database consisting of a merged file of fiscal and classroom variables. Multiple regression analysis was used in a cross-validation design to develop CE models predictive of Chapter 1 reading and math programs. The final set of predictors was conceived as two composites: the first set largely under the control of state education agency administrators and the second under local education agency program managers. The first composite is a district size effect: Chapter 1 projects in larger districts are more cost-effective than those in smaller districts. The primary implication of this finding points to the need to consolidate smaller Chapter 1 projects into larger districts. The second composite shows cost-effective practices and policies found in larger Chapter 1 projects. These include teacher aide programs, shorter time blocks for math instruction, and an emphasis on small group, inclass instruction. Five technical appendixes are included: expanded regression models, regression summary tables, correlation matrix, T-test tables, and cross-validation tables. (Author/TE)

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COST-EFFECTIVENESS PREDICTORS IN CHAPTER 1 PROGRAMS:

THE MINNESOTA EXAMPLE

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EXECUTIVE SUMMARY

Reductions in the funding of compensatory education along with observed discrepancies in per-pupil cost among school districts that are equally effective in producing achievement gains created a compelling case for the study of the determinants of cost-effective Chapter 1 programs in the state of Minnesota. Cost-effectiveness (CE) indices for Chapter 1 reading and math services were constructed which reflected a ratio between a district's weighted mean NCE gain and the average per-pupil cost; higher scores on the index indicated better CE than lower scores.

A random sample of 141 Chapter 1 programs participated in the study in which the data base consisted of a merged file of fiscal (UFARS data) and classroom (TIERS data) variables. Multiple regression analysis was used in a cross-validation design to develop CE models which were predictive of Chapter 1 reading and math programs. The final set of predictors was conceptualized as two composites; the first set is largely under the control of SEA administrators whereas the second is more under the control of LEA program managers.

The first composite is a district size effect: Chapter 1 projects in larger districts are more cost-effective than those located in smaller districts. The primary implication of this finding points to the need to consolidate smaller Chapter 1 projects into larger districts. The second composite essentially reflects cost-effective practices and policies found in larger Chapter 1 projects. These include the use of teacher aide programs, shorter time blocks for math instruction, and an emphasis on small group, in-class instruction.

INTRODUCTION

A major goal of the Minnesota State Department of Education (MSDE) in recent years has been to identify and implement effective Chapter 1 practices that can serve more children at lower costs. Yet achievement of that goal had eluded MSDE officials until the matter of Chapter 1 program cost-effectiveness could be investigated systematically. This goal has now been accomplished by an eighteen-month study funded through a Federal grant from the U.S. Department of Education under the Secretary's Initiative to Improve Chapter 1 ECIA Projects. In a collaborative effort with the Region II Evaluation Technical Assistance Center (TAC) operated by Advanced Technology, Inc., the MSDE set forth to investigate exemplary Chapter 1 practices used by those school districts providing effective services at comparatively low cost, and to disseminate these cost-effective management techniques to their less efficient neighbors. As a criterion of cost-effectiveness, the MSDE chose a district-level metric representing the dollar cost per pupil, per unit of NCE gain. The ultimate objective of the study was to relate the variance in this cost-effectiveness index to a number of curricular and management variables.

The impetus to identify and disseminate research-based information concerning cost-effective delivery of Chapter 1 services stems from the current condition of compensatory education in which severe budget restraints exist while large discrepancies are observed in per-pupil costs among school districts that are equally effective in terms of NCE gains. From a management perspective

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in an era of fiscal austerity, this situation creates a compelling reason for isolating the determinants of cost-effective school practices so that dwindling education funds might be spent both more efficiently as well as effectively in the future. Yet during the last decade limited improvement has been made in identifying variables related to overall achievement, the majority of which are not easily manipulated at either the state or local level. On the other hand, data related to cost efficiency is scarce at best. This history notwithstanding, the designers of the present study felt that the fiscal management and evaluation reporting systems currently in use by Minnesota Chapter 1 programs held potential for identifying manipulable factors which might prove useful in modeling cost-effectiveness predictors of exemplary compensatory education practices.

Our approach was to utilize the methodology of cost-effectiveness (CE) analysis for developing models by which we could identify a specific set of variables predictive of school districts exhibiting high educational achievement at comparatively low cost per pupil. Toward this end, we constructed CE indices for Chapter 1 math and reading services which reflected a ratio between a district's weighted mean NCE gain per pupil and the average per pupil cost. The magnitude of our CE index was determined by the values taken from a district's data base and the index was constructed so that increasing criterion scores reflected better cost-effectiveness than lower criterion scores. Negative scores on the CE index reflect losses in educational achievement purchased at a relatively high cost per pupil; increasing positive scores show higher educational attainment at relatively low cost to the district. Thus, our CE index provided us with a criterion to measure what Thompson (1980) has referred to as "the trade-off between program gains and money losses" (p. 230).

METHODOLOGY

Stepwise multiple regression analysis was the principal statistical technique used in the study in which five models were developed to identify educationally significant predictors of cost-effective Chapter 1 programs. Two of these models involved cost-effectiveness equations, one for reading and the other for math programs. The remaining three models examined the separate components of the two cost-effectiveness equations: reading effectiveness, math effectiveness, and cost per pupil. Independent variables entered into these five regression equations were obtained by merging data from separate fiscal and classroom data bases. A naturalistic case study investigation was then implemented subsequent to the development of the final regression models. The purpose of this field study component was to examine how selected predictor variables actually operated in practice and to obtain local perspectives on the interpretation of the data. The overall study was concluded with a cross-validation statistical procedure in which the generalizability of the regression models was estimated.

Sampling Design

One third of Minnesota's public school districts were randomly selected for participation in the study; this yielded a random sample of 141 Chapter 1 projects. The data base analyzed for these 141 cases was developed by merging two files: (a) the Uniform Financial Accounting and Reporting System (UFARS) which is used by Minnesota schools for their Chapter 1 accounts; and (b) the Title I Evaluation and Reporting System (TIERS) which is used to report descriptive and achievement test data for Chapter 1 projects at the district level. Data from grades 2 and 6 for public schools were sampled from these reports.

The regression analyses were conducted with data obtained from the FY83 UFARS/TIERS reports; 129 valid cases composed the derivation sample. The validation sample was composed of 80 cases selected at random from the FY84 UFARS/TIERS reports. The residuals analysis of the FY83 data (n=129) was used to select a 10 percent subsample (n=12) for follow-up interviews and site visits, the purpose of which was described above. Sites selected were those districts for which the CE models were reasonably predictive and which also exhibited relatively high CE indices.

Analysis Procedures

Extensive exploratory analyses (e.g. Tukey, 1977) using descriptive and correlational procedures led to the construction and selection of independent variables, most of which required transformations in order to meet the assumptions of parametric statistical analysis. Subsequent regression analyses refined the list of predictors further. Primary criteria in delimiting the final models included considerations of (a) R Square values; (b) independent variable influences on R Square changes; (c) the size of B-weights; (d) significance values, (e) simple and partial correlations with the criterion measures, and (f) the standard error of estimate associated with a given model The logic employed in selecting the final predictor sets from competing models was influenced by recent thinking on the use of multiple regression analysis (e.g. Achen, 1982; Cohen and Cohen, 1983). In our case, educational significance (i.e., relevance to policy and practices) sometimes outweighed considerations of statistical significance, and as a general rule, we tried to select those models which maximized R^2 while minimizing the standard error of estimate. Post hoc comparison tests were also conducted to obtain additional evidence for judging the merit of retaining certain variables in the final models.

The use of multiple regression analysis for the purpose of prediction requires cross-validation in order to determine how well the regression equations derived from one sample work on other samples from the same population. In our procedure, we used the b-weights obtained from the final variables in the derivation sample models to construct ten prediction equations. Five of these equations were "core" models which reflected the cleanest and most parsimonious explanations from a purely statistical point of view. The other five equations were "expanded" models which contained a larger number of variables whose selection was based on both statistical and educational grounds. Using the validation sample, the criterion variables were computed for the predicted and actual values of the data for both core models and expanded models. These predicted and actual values were then correlated for a given model and the shrinkage in the R^2 values was noted.

In the follow-up interview study component, mini-case studies were written for each of the twelve sites visited. These case studies were organized around issues examined on-site through a semi-structured site visit guide. Each case study was content analyzed and patterns in the data examined using a qualitative perspective (e.g. Patton, 1980).

DISCUSSION OF MAJOR FINDINGS

The reader will recall that five models were developed: two cost-effectiveness models (one for reading CE and the other for math CE), and three related models examining the separate effectiveness and cost components of the CE models. The findings reported here emphasize the results obtained from the two cost-effectiveness models. Results pertaining to the two effect models and the cost model are discussed to the extent that they shed light on understanding the cost-effectiveness models. Discussion of the qualitative data

from the follow-up interviews is also restricted to issues of interpretation with respect to cost-effectiveness concerns.

The major findings of the study are reviewed in five sections. In the first section, we discuss "goodness of fit" considerations with respect to how well our cost-effectiveness models account for the observed data. Cost-effectiveness predictors common to both reading and math programs are reviewed in the second section. Factors unique to reading are discussed in the third section followed by a discussion of those factors unique to math programs. Results of the cross-validation analysis are reported in the final section.

The Cost-Effectiveness Models: Goodness of Fit Considerations

The "expanded" theoretical models for cost-effectiveness in reading and math are displayed in Tables 1 and 2 in Appendix A. The eight variables in the reading model account for about half of the variance in Chapter 1 reading cost-effectiveness (R^2 = .48) while the eight variables in the math model account for about a third of the variance (R^2 = .33) in Chapter 1 math cost-effectiveness. Thus, a good proportion of the variation in Chapter 1 cost-effectiveness is "explained" by those variables in Tables 1 and 2. However, the statistical "core" of both models is composed of three common variables which account for the major portion of the variance in Chapter 1 cost-effectiveness. These three variables are district size (i.e. total student enrollment), Chapter 1 budget (i.e. the sum of actual UFARS expenditures), and entering student achievement level (i.e. pretest score). Together, these predictors account for 42 percent and 27 percent respectively of the variation in reading and math cost-effectiveness (see the Summary Tables in Appendix B for further details).

Although the core models and the expanded models explain a respectable portion of the variance in Chapter 1 cost-effectiveness, thus providing a "good fit" in terms of an R^2 measure, none of the models are particularly strong from a predictive perspective. While both cost-effectivenss (CE) models maximize R^2 values and minimize prediction errors, the standard error of the regression estimate associated with each CE model is relatively large. In the case of reading, the cost-effectiveness criterion index ranges from a low of -.014 to a high of +.128 with a median value of +.014. Assuming a school district's Chapter 1 reading program was estimated to have a cost-effectiveness index around the 50th percentile, based on our expanded model's standard error of regression estimate the true index could be anywhere from about the 20th percentile to the 70th percentile. Such relatively weak predictive power essentially holds for estimates of math cost-effectiveness as well. On balance, the CE models in the derivation sample showed no significant pattern for either underprediction or overprediction; they simply displayed relatively poor predictive power.

Predictors Common to Reading and Math Cost-Effectiveness

The following five variables all appear to influence the cost-effectiveness of Chapter 1 reading and math programs: (1) district size; (2) total budget; (3) student entering achievement; (4) that proportion of the budget spent on licensed teachers; and (5) that proportion of the budget spent on teacher aides. Each predictor variable is discussed in turn.

District Size. The single, most influential variable related to Chapter 1 cost-effectiveness is district size. Our data indicate that the larger the district, the more cost-effective a Chapter 1 program tends to be. Specifically, larger school districts tend to be more effective than smaller districts in

terms of NCE gains, have lower per-pupil costs, and are more cost-effective (see, for example, Table 1 in Appendix D). As a point of reference, the median district size in the derivation sample had a total enrollment of 840 students.

In addition, larger districts tend to spend proportionately more of their budgets on teacher aides and supplies, both of which are related to the criterion variables. Larger districts also tend to spend proportionately less of their budgets on licensed teachers and more on teacher aides compared to smaller districts. These variables are discussed more fully below. The reader is referred to the Technical Appendices for supporting statistical information (e.g. Appendix C).

Why is district size so influential? How can the effect of district size on cost-effectiveness be understood? The answers partially lie in understanding the separate effect models and the cost model. First, the lower cost-per-pupil associated with larger districts is perhaps a statistical byproduct of how Chapter 1 programs are funded relative to a district's enrollment. The Orshansky Index controls Chapter 1 funding allocations and is based not on enrollment counts, but on LEA poverty counts. Hence, it is plausible that Chapter 1 budget allocations tend to be decreasingly proportional to increasing district enrollment levels. Although district size and Chapter 1 budget levels are positively correlated, once the influence of district size has been removed, the effect of budget level on the CE index becomes <u>negative</u>! The interview data also suggest an "economy-of-scale" hypothesis relative to the cost issue. Specifically, Chapter 1 programs in larger school districts tend to save on the expenses associated with supplies and professional development activities by relying on the district's general fund to cover these opportunity costs; both of these kinds of expenses are related to the Chapter 1 CE index.

The interview data also point to a "talent/resource pool" interpretation of the district size effect. All twelve of the exemplary sites visited in the field study component were considerably well above the median in terms of district size; the average enrollment level for the follow-up sites placed this group as a whole at the 81st percentile. All of these LEA sites were located in or near an urban community from which they could draw on the abundant availability of qualified personnel as teachers, aides, and/or for technical assistance support at relatively low cost due to the oversupply of teaching professionals in a glutted education market. Overall, about a third of the staffs in these exemplary programs were certified teachers working as teacher aides. And in all cases, the instructional staffs worked part-time (mean FTE = .60) and were generally paid aide-level wages regardless of whether their job description was that of a licensed teacher or a teacher aide. A particularly cost-effective management practice used by the very large districts (where multiple school buildings needed to be staffed) was to match a teacher's FTE level to the Chapter 1 case load of a particular building. In other words, a teacher's contracted FTE was based on the concentration of Chapter 1 students in a given target school.

Chapter 1 Budget. The influence of budget levels on the CE index seems to operate through the district size effect as discussed above. Once the effect of district size is controlled, the influence of budget on CE is negative. When district size is not controlled, there is almost no relationship between budget and CE. These data seem to suggest that the lower cost-per-pupil associated with larger districts is either a statistical artifact of the Orshansky funding formula, an indication of less efficient use of larger budgets with larger administrative staffs, or both.

Entering Achievement Level. Initial student ability, as measured by an achievement pretest, is negatively related to effectiveness and has no relationship to cost. This negative relationship to CE is mediated apparently through the effect models. One interpretation of these data is similar to that of "regression to the mean" in the sense that low scoring students at pretest will tend to gain the most when measured at posttest, and vice versa. Another interpretation is that student selection policies are more effective when the lowest achievers are targeted for Chapter 1 services.

Licensed Teachers versus Teacher Aides. From a statistical perspective, a rather murky picture emerges when attempting to unravel the trade-offs in cost-effectiveness regarding the relative payoffs associated with investing Chapter 1 funds in licensed teachers versus teacher aides. To be sure, licensed teachers significantly contribute to increasing per-pupil costs, whereas aide salaries have little to no direct cost impact. The differential effect of teachers versus aides on producing NCE gains is weak and inconsistent across reading and math programs; the only consistent direct relationship is that of a small, negative influence on math effectiveness as a function of investing greater proportions of a Chapter 1 budget on instructional staff. (The reader is referred to the tables in Appendix A and C, and to Table 2 in Appendix D; particular attention should be paid to Table 4 in Appendix A.) Overall, there appears to be no earth shaking difference in the cost-effectiveness of investing differentially in licensed teachers versus teacher aides. However, the partial correlations displayed in Tables 1 and 2 of Appendix A suggest that increasing investments into instructional line items may have a negative influence on a Chapter 1 program's overall cost-effectivenss (i.e., raising the proportion of the budget associated with instructional salaries may tend to lower a district's CE index).

As with other variables, the effect of teachers and aides on Chapter 1 cost-effectiveness seems to be mediated by the district size effect. Our data suggest that as district size increases, there is a tendency to invest more in teacher aides and less in licensed teachers (see Appendix C). For example, we found in the field study component that the majority of exemplary programs (which were all large LEAs) were primarily aide-based delivery systems in which licensed personnel were utilized as supervising lead teachers. Most of these aide-based delivery systems reflected a shift in program design from licensed teachers to teacher aides as a cost-cutting strategy forced by budget reductions stemming from the early to mid-1970's. But even those programs portrayed on paper as teacher-based programs operated in reality more like aide programs in the sense that (1) FTE allocations reflected part-time employment, and (2) many "aide" programs utilized licensed teachers for a majority of their staff coverage. In short, most of these large LEA exemplary projects could not be differentiated on the basis of actual staffing patterns other than by staff labeling practices on paper. If it is difficult to distinguish "aide programs" from "teacher programs" when you see them in the field, it should not come as much of a surprise when statistical computations appear to be at least equally blind.

Predictors Unique to Reading Cost-Effectiveness

The following three variables appear to influence a Chapter 1 program's cost-effectiveness in the area of reading but not math instruction: (1) the proportion of the budget spent on supplies/materials; (2) project setting; and (3) the proportion of the budget spent on administrative overhead. Each predictor is discussed in turn.

Supplies/Materials. Investing in supplies to support Chapter 1 reading instruction appears to have a positive influence on cost-effectiveness. As a

proportion of the Chapter 1 budget, the average Minnesota program spends so little on supplies that the mean value approaches zero; the high water mark is 12%. Nevertheless, expenditures on supplies appear to pay off as a cost-effective investment of Chapter 1 funds, particularly for reading instruction. Data from the field study component suggest that greater investment in supplies/materials supports instructional flexibility by broadening the range of teaching strategies that can be used to address student learning objectives. A common theme across the exemplary projects involved the use of supplies/materials in a gaming approach to instruction in which reading games were an integral part of motivating students to learn and which also provided direct feedback to the student. Investments in supply lines also went toward developing Chapter 1 libraries and supported teacher-made instructional materials.

Project Setting. Does it really make a difference whether reading instruction occurs in the regular education classroom or in a pull-out setting? While 78% of the Chapter 1 projects in the derivation sample utilized pull-out settings, our data suggest that in-class settings may be slightly more cost-effective for reading instruction. The t-test data (see Appendix D, Table 3) indicate that although both settings are equally effective, the pull-out setting is more costly and shows a trend toward lower cost-effectiveness than in-class instruction. Why this might be is unclear.

The correlation data in Appendix C suggest that differential staffing patterns may account for these findings. Specifically it appears that licensed teachers might be used more in pull-out settings whereas teacher aides might be associated more with in-class reading group instruction. Such a pattern could explain why pull-outs are more costly since teachers generally are more expensive than aides. However, we were not able to substantiate this

hypothesized staffing pattern in the field study due to the relatively small sample size (i.e. 12 case studies).

The field study component did surface a polarization of attitudes as to why a Chapter 1 program would adopt a particular instructional setting. In no case had there been systematic study of the issue. Those favoring pull-out practices (75% of the sites visited) were basically antagonistic toward implementing compensatory education instruction within the regular education classroom. These respondents felt that in-class intervention would be too disruptive to the mainstream class (e.g. "too many cooks spoil the broth") and that the Chapter 1 students would suffer from being labeled as special education children. Those favoring the in-class instruction approach felt the opposite was true and that both disruption and labeling were myths. The in-class setting advocates also pointed out that they could achieve (1) better coordination between the Chapter 1 and regular education staff, (2) greater ownership of Chapter 1 students by the regular teachers, (3) greater time-on-task since transition time to a pull-out setting was eliminated, and (4) a more appropriate support role for the Chapter 1 instructor, particularly if that person was a teacher aide.

Administration. Using Chapter 1 funds to offset administrative overhead (i.e. declining to waive Chapter 1 administrative costs which can be picked up through the district's general fund) has a negative influence on cost-effectiveness, particularly in the area of reading instruction (which most Chapter 1 programs do offer as opposed to math instruction which tends to be less available in Minnesota). In many of the exemplary projects visited during the field study component, administrative overhead was, in fact, absorbed by the district's general fund and not charged to the Chapter 1 account. In short, cost-effective administrators tended to donate their time and money to Chapter 1. An exception to this pattern involved some aide-based programs where the

lead teacher doubled as the Chapter 1 director and drew her/his salary from the instructional line.

Predictors Unique to Math Cost-Effectiveness

The following three variables appear uniquely to influence a Chapter 1 program's cost-effectiveness in the area of math instruction: (1) Professional Development; (2) Student-Teacher Ratio; and (3) Cumulative Hours of Instruction Per Year. Each predictor is discussed in turn.

Professional Development. Investing in professional development opportunities (by either paying for inservice training within the district or by providing funds to travel outside the district for inservice opportunities) appears to have some positive influence on Chapter 1 cost-effectiveness in the area of math instruction (see Appendix A, Table 2). Obviously, those Chapter 1 programs with larger budgets can afford to support more inservice opportunities and that is what our correlation data suggest. The way in which professional development seems to operate as a cost-effective investment can be glimpsed through our interview data. On the effectiveness side, professional development helps to maintain and increase staff instructional skills, particularly in learning how to make math instruction games (i.e. utilizing supplies/materials for instructional purposes). Inservice was also cited as helping staff to develop precision teaching and diagnostic-prescriptive approaches to instruction. On the cost side, most districts do not pay very much to obtain professional development activities and many write-off such expenses to the district's general fund (see Economy of Scale Hypothesis in the discussion of the District Size Effect).

Student-Teacher Ratio. Does student-teacher ratio make a difference? In math instruction, the use of small groups appears to be a more cost-effective approach than 1:1 individualized instruction. As a result of findings from the

field study and subsequent statistical tests of emerging hypotheses, it appears that small groups of 2-5 students are optimal for enhancing a Chapter 1 program's cost-effectiveness in math instruction. We speculate that these group sizes probably facilitate a gaming approach to learning math. A classroom observation study would be required to test this hypothesis more fully. We do know, however, that small group instruction (particularly in groups of 2-5 students) is less costly, more effective, and more cost-effective than alternative grouping strategies; we also know that these differences are not related to the amount of instruction received by Chapter 1 students. The reader is referred to Tables 2 and 5 in Appendix A, and to Table 4 in Appendix D for supporting detail.

Hours of Instruction per Year. In Chapter 1 math, less seems to be better than more; instruction time that is. The data in Tables 2 and 4 of Appendix A show a negative correlation between the CE index and total hours of instruction per year which suggests that cost-effective math programs spend less time instructing math than their less efficient neighbors. What we found when we went on-site was just that: exemplary Chapter 1 projects on the average allocated half the instructional time to math teaching compared with the state norm of 90 hours. This converts to about a 15 minute instruction block per day as compared with the more typical half-hour allocation for math instruction. Our exemplary respondents showed a pattern of "small dosage instruction" for math which they coupled with an early exit policy geared to either a mastery learning system and/or the midyear student needs assessment. And that's how their students spent half the usual amount of time in math instruction and that's how we account for the influence of instruction time on cost-effectiveness.

Cross-Validation of the Predictors

In the cross-validation procedure, we were trying to estimate not only the validity of our prediction equations but to identify which of the cross-validated models gave us the best predictions. Adding predictors to a multiple regression equation tends to increase the R^2 values up to a point. We can see this by referring to the expanded and core models in Appendix B; the expanded models have more predictors and larger R^2 values. However, the greater the number of predictors, the more unstable are the derivation sample regression weights (i.e. the B-weights). This phenomenon tends to decrease or shrink the R^2 values in the validation sample (Herzberg, 1969). It is also fairly well known that when a relatively large number of predictors is used in multiple regression analysis, a subset of them often predict just as well, if not better. From the standpoint of parsimonious explanation, the problem is determining that subset of predictors; the core models in our study represent those probable subsets.

The immediate question, then, is "which models offer the best prediction without sacrificing stability?" Stated differently, we want to determine that set of predictor models (core vs. expanded) which are most significantly correlated to the actual criterion measures and at the same time exhibit the least shrinkage in R^2 values.

Tables 1-5 in Appendix E compare predictions of the core vs. expanded models against the actual values of a criterion variable. With the exception of the cost model, the core set of predictors tends to show mean estimates closer to the actual criterion values, exhibit as good or better correlations, and have the added attraction of more parsimonious explanation. Table 6 of Appendix E substantiates these cross-validity claims in terms of shrinkage minimization standards; this table also suggests that our core math models are more stable

than the reading models although less variance is accounted for. The expanded cost model occupies a middle ground of prediction stability; it is more stable than predictions for reading cost-effectiveness but less stable than predictions for math cost-effectiveness.

So which variables are our best predictors of cost-effective Chapter 1 programs? Based on the above discussion, a primary composite to consider and which is mainly under the control of state-level administrators involves the following three variables:

- District size
- Chapter 1 Budget Allocations
- Entering Student Achievement Level (Implications for student selection policy)

A secondary composite, mostly under the control of local administrators, is also worth considering. This composite is composed of the following variables:

- Cumulative Hours Math Instruction
- Teacher Aide Programs
- In-Class Instruction
- Small Group Instruction

IMPLICATIONS FOR POLICY AND PRACTICE

The strongest, direct positive influence on cost-effectiveness in Minnesota Chapter 1 programs is district size: Chapter 1 programs in larger districts are more effective, less costly to operate per pupil, and are hence more cost-effective than Chapter 1 programs in smaller districts. The influence of the remaining predictors seems to operate more in an indirect way, mediated largely through practices and policies associated with larger school districts. This seems to be more characteristic of the secondary composite than of the remaining two variables in the first composite.

Our data suggest that larger Chapter 1 budgets and higher student entering achievement have a "negative" influence on Chapter 1 cost-effectiveness. In regard to the influence of budget size, the data suggest that Chapter 1 funds might be used more efficiently in larger districts where more staff are required to implement the program. As noted earlier in this paper, a cost-efficient management practice under these circumstances is to match the contracted FTE of instructional personnel to the Chapter 1 case load of a particular school site. As to the influence of entering student achievement level, our data seem to suggest that the most effective student selection policy is that of targeting Chapter 1 services for those students with the lowest pretest achievement scores.

While additional implications might be drawn for policies related to funding allocations and student selection/achievement testing practices, these two areas may indeed reflect statistical artifacts having little real bearing on Chapter 1 cost-effectiveness. It might also be somewhat futile to draw implications for modifying factors beyond the control of Minnesotans. Both the Orshansky Index and Chapter 1 student selection practices are highly influenced by the Federal policy context which tends to operate as a constraint on state-level options for promoting change from within.

What are the implications of the district size effect which could positively influence cost-effectiveness and which are under the control of state or local education administrators in Minnesota? Two major possibilities come to mind:

- District Consolidation
- Promoting Cost-Effective Practices Associated with Large LEAs

These two options are not mutually exclusive; either or both could be developed. The first option is primarily under the control of state department

of education administrators whereas the second option is more under the control of local education agency administrators. Some issues associated with these options are reviewed below.

District Consolidation

Consolidation would likely bring greater resources to bear in making smaller districts more cost-effective. Consolidating small districts into larger districts could plausibly result in newly realized benefits from greater financial and human resource pools which, if invested wisely, could create more efficient and effective compensatory education programs. Consolidation could also resolve the longstanding problem of unreliable and/or negative NCE gains associated with small Chapter 1 programs. Such consolidation might be achieved through a consortium/cooperative approach or through the more conventional manner involving physical changes impacting bond issues, building construction, staff and pupil reassignment, and so forth. The latter would no doubt be more disruptive than the former approach and be met with greater opposition. Consolidation is also likely to result in more cost-effective educational policy and practice being promoted as a result of the influence of high quality personnel being attracted to, infused in, or involved with a district that has been expanded.

Promoting Cost-Effective Practices Associated with Large LEAs

A Chapter 1 program would not necessarily have to operate through a large district in order to develop cost-effective practices exhibited in larger systems; but it would probably help. Nevertheless, some of those practices discovered through the field study component could be promoted through various forms of technical assistance and might involve various modifications in program design and instructional policies/practices. These are reviewed below in terms

of patterns we saw in the operation of exemplary cost effective Chapter 1 programs.

Coordination of instructional planning and implementation between regular and compensatory education staff was seen as critical. Such coordination was typically facilitated by weekly meetings to share information on the continued development of lesson plans. These lesson plans tended to be written lesson plans which coordinated instruction between the two staffs in regard to children under joint educational responsibility, and which reflected curricular developments beyond the PEP form.

As stated previously in this paper, math instruction reflected a "short dosage approach" in which the program was administered under an early exit policy. Students' length of stay in the program was typically gauged by a mastery learning approach to instruction and/or where the midyear needs assessment was utilized as a student monitoring system designed to adjust educational planning decisions.

Aide-based delivery systems directed by lead teachers or part-time licensed teacher systems were the rule, not the exception. Since aide-based programs appear to be less costly and about equally effective, such program designs deserve to be promoted and examined further by administrators seeking a way out of a budget crunch. The use of teacher aides for in-class instruction with small groups appears to hold particular promise. This suggestion is consistent with the findings of Levin et al. (1984) in which a combined peer and adult program of "cross-age tutoring" seems to be a particularly cost-effective approach to instruction.

Feasibility studies and further investigation into the desirability of implementing changes along the lines reviewed above may be warranted before specific action plans or recommendations are issued.

Some Final Thoughts

The methodological developments made to date in modeling cost-effectiveness predictors does provide a basis for identifying school districts in the greatest need for technical assistance from the Area Director. Such efforts could be facilitated by the Regional Chapter 1 Evaluation Technical Assistance Center which might utilize modeled data to help diagnose specific areas where intervention assistance could initially be targeted. Our cost-effectiveness modeling could also be utilized as a basis for nominating exemplary projects for public recognition under the Secretary's Recognition Program and for JDRP review.

Further refinement in modeling our index is needed, however, before this methodology can reliably be used in the program application process to estimate funding allocation parameters or program goal achievement. Such extensions to program planning and evaluation are attainable with sustained efforts to develop multiple regression analytic approaches to the modeling of cost-effectiveness parameters.

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TECHNICAL APPENDICES

APPENDIX A

THE EXPANDED REGRESSION MODELS

Table 1: THE EXPANDED READING COST-EFFECTIVENESS MODEL

Model Entry	Independent Variable	Simple R	Partial R Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	B Weight Significance
Step 1	District Size	.45								P = .001
Step 2	Chapter 1 Budget	.01	-.45							P = .001
Step 3	Entering Achievement	-.40	-.32	-.30						P = .001
Step 4	Supplies/Materials	.23	.18	.16	.15					P = .08
Step 5	Project Setting'	-.14	-.07	-.13	-.13	-.14				P = .15
Step 6	Licensed Teachers	-.22	-.13	-.11	-.13	-.13	-.11			P = .01
Step 7	Administration	-.13	-.19	-.12	-.11	-.11	-.10	-.16		P = .01
Step 8	Teacher Aides	.23	.11	.08	.11	.11	.09	-0-	-.16	P = .08

Model R^2 = .48
Standard Error of Regression Estimate = .0150 CE Index Units

' Coded as a dummy variable; the negative correlation suggests that in-class reading instruction tends to be more cost-effective than pull-out settings. Note, however, that the influence of project setting is statistically nonsignificant by conventional standards of reliability.

Table 2: THE EXPANDED MATH COST-EFFECTIVENESS MODEL

Model Entry	Independent Variable	Simple R	Partial R Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	B Weight Significance
Step 1	District Size	.34								P = .001
Step 2	Chapter 1 Budget	-.03	-.38							P = .001
Step 3	Entering Achievement	-.12	-.12	-.18						P = .10
Step 4	Professional Development	.11	.09	.16	.14					P = .14
Step 5	Student-Teacher Ratio'	-.14	-.09	-.10	-.12	-.13				P = .08
Step 6	Hours Instruction Per Year	-.26	-.21	-.16	-.11	-.11	-.11			P = .25
Step 7	Licensed Teachers	.04	-.04	-.01	-.04	-.02	-.02	-.03		P = .02
Step 8	Teacher Aides	-.12	-.07	-.11	-.09	-.09	-.11	-.10	-.18	P = .04

Model R^2 = .33
Standard Error of Regression Estimate = .0198 CE Index Units

' Coded as a dummy variable; the negative correlation suggests that small group instruction in math is more cost-effective than 1:1 instruction. This variable is statistically significant under a decision rule setting the confidence interval at 90% (i.e. a p value of .10 or less).

Table 3: THE EXPANDED READING EFFECTIVENESS MODEL

Model Entry	Independent Variable	Simple R	Partial R Step 1	Step 2	Step 3	Step 4	Step 5	B Weight Significance
Step 1	Entering Achievement	-.53						P = .001
Step 2	District Size	.36	.26					P = .001
Step 3	Chapter 1 Budget	.06	-0-	-.25				P = .02
Step 4	Professional Development	-.12	-.12	-.15	-.13			P = .15
Step 5	Administration	-.13	-.12	-.15	-.11	-.11		P = .21
Step 6	Supplies/Materials	-.19	.15	.12	.10	.11	.11	P = .22

Model R^2 = .40
Standard Error of Regression Estimate = 4.521 NCEs

Table 4: THE EXPANDED MATH EFFECTIVENESS MODEL

Model Entry	Independent Variable	Simple R	Partial R Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	B Weight Significance
Step 1	Entering Achievement	-.29								P = .002
Step 2	Hours Instruction Per Year	-.24	-.18							P = .26
Step 3	District Size	.15	.15	.12						P = .002
Step 4	Chapter 1 Budget	-.02	-.05	-.05	-.19					P = .05
Step 5	Teacher Aides	-.14	-.11	-.11	-.16	-.18				P = .006
Step 6	Licensed Teachers	.05	.01	.02	.05	.06	-.14			P = .03
Step 7	Administration	-0-	.01	.01	-0-	.04	.02	-.12		P = .17
Step 8	Supplies/Materials	-.01	-.04	-.05	-.07	-.09	-.10	-.11	-.12	P = .18

Model R^2 = .22
Standard Error of Regression Estimate = 6.470 NCEs

Table 5: THE EXPANDED COST MODEL

Model Entry	Independent Variable	Simple R	Partial R Step 1	Step 2	Step 3	Step 4	B Weight Signficance
Step 1	District Size	-.36					P = .001
Step 2	Chapter 1 Budget	-.04	.30				P = .001
Step 3	Instructional Grouping[1]	-.23	-.24	-.25			P = .01
Step 4	Licensed Teachers	.32	.26	.25	.23		P = .01
Step 5	Project Setting[2]	.20	.14	.17	.13	.10	P = .26

Model R^2 = .30
Standard Error of Regression Estimate = $223.72

[1] Coded as a dummy variable; the negative correlation suggests that per-pupil cost increases as a function of group size in terms of student-teacher ratio collapsed over both reading and math instruction.

[2] Coded as a dummy variable; the positive correlation suggests that pull-out settings contribute more to average per-pupil cost than does inclass instruction. However, the b-weight for the influence of overall project setting is statistically non-significant.

APPENDIX B

REGRESSION SUMMARY TABLES

Summary Table 1: STEPWISE MULTIPLE REGRESSION TO PREDICT COST-EFFECTIVENESS IN READING

Step	Variable Entered'	F to Enter	P Value Variable	Multiple R	R^2	R^2 Change	Simple R	Overall F	P Value Model
1	District Size	31.39	.0001	.445	.198	.198	.45	31.39	.001
2	Chapter 1 Budget	31.96	.0001	.600	.360	.162	.01	35.50	.001
3	Entering Achievement	12.64	.001	.647	.419	.059	-.40	30.07	.001
4	Supplies/Materials	2.74	.10	.657	.432	.013	.23	23.55	.001
5	Project Setting	2.59	.11	.665	.444	.012	-.14	19.60	.001
6	Licensed Teachers	1.58	.21	.671	.451	.007	-.22	16.68	.001
7	Administration	3.18	.07	.681	.465	.014	-.13	15.01	.001
8	Teacher Aides	3.11	.08	.691	.478	.013	.23	13.75	.001
9	Professional Development	.74	.39	.693	.482	.004	.06	12.28	.001

'Statistical Core Model = Variables Entered at Step 3
Expanded Theoretical Model = Variables Entered at Step 8

Summary Table 2: STEPWISE MULTIPLE REGRESSION TO PREDICT COST-EFFECTIVENESS IN MATH

Step	Variable Entered'	F to Enter	P Value Variable	Multiple R	R^2	R^2 Change	Simple R	Overall F	P Value Model
1	District Size	16.83	.001	.342	.117	.117	.34	16.83	.001
2	Chapter 1 Budget	21.26	.001	.494	.244	.127	-.03	20.39	.001
3	Entering Achievement	4.10	.04	.518	.268	.024	-.12	15.29	.001
4	Professional Development	2.57	.11	.532	.283	.015	.11	12.26	.001
5	Student-Teacher Ratio	2.22	.13	.544	.296	.013	-.14	10.35	.001
6	Hours Instruction Per Yr.	1.55	.21	.552	.305	.009	-.26	8.92	.001
7	Teacher Aides	1.12	.29	.558	.311	.006	.04	7.82	.001
8	Licensed Teachers	3.99	.04	.577	.333	.022	-.12	7.51	.001
9	Prof. Dev. & Consultants	.14	.70	.578	.334	.001	.11	6.64	.001
10	Supplies/Materials	.02	.88	.578	.334	.000	.12	5.93	.001

'Statistical Core Model = Variables Entered at Step 3
Expanded Theoretical Model = Variables Entered at Step 8

Summary Table 3: STEPWISE MULTIPLE REGRESSION TO PREDICT READING EFFECTIVENESS

Step	Variable Entered'	F to Enter	P Value Variable	Multiple R	R^2	R^2 Change	Simple R	Overall F	P Value Model
1	Entering Achievement	49.48	.001	.529	.280	.280	-.53	49.48	.001
2	District Size	9.20	.003	.573	.329	.049	.36	30.94	.001
3	Chapter 1 Budget	8.18	.005	.608	.370	.041	.06	24.53	.001
4	Professional Development	1.99	.16	.616	.380	.010	-.12	19.04	.001
5	Administration	1.51	.22	.622	.388	.008	-.13	15.60	.001
6	Supplies/Materials	1.51	.25	.628	.395	.007	.19	13.30	.001
7	Licensed Teachers	.04	.83	.629	.395	.000	-.07	11.32	.001
8	Teacher Aides	.45	.50	.630	.398	.003	.10	9.92	.001
9	Project Setting	.04	.82	.631	.398	.000	-.05	8.75	.001
10	Prof. Dev. & Consultants	.04	.83	.631	.398	.000	-.10	7.81	.001

' Statistical Core Model = Variables Entered at Step 3
Expanded Theoretical Model = Variables Entered at Step 6

Summary Table 4: STEPWISE MULTIPLE REGRESSION TO PREDICT MATH EFFECTIVENESS

Step	Variable Entered'	F to Enter	P Value Variable	Multiple R	R^2	R^2 Change	Simple R	Overall F	P Value Model
1	Entering Achievement	11.79	.001	.291	.085	.085	-.29	11.79	.001
2	Hours Instruction Per Yr.	4.29	.04	.339	.115	.030	-.25	8.19	.001
3	District Size	1.91	.16	.358	.129	.014	.15	6.14	.001
4	Chapter 1 Budget	4.50	.03	.398	.159	.030	-.02	5.86	.001
5	Teacher Aides	4.00	.04	.430	.186	.027	-.14	5.60	.001
6	Licensed Teachers	2.29	.13	.447	.201	.015	.05	5.10	.001
7	Administration	1.70	.19	.460	.212	.011	.00	4.64	.001
8	Supplies/Materials	1.76	.18	.472	.223	.011	-.01	4.30	.001
9	Student-Teacher Ratio	1.47	.22	.482	.233	.010	-.07	4.00	.001
10	Prof. Dev. & Consultants	.71	.40	.487	.237	.004	-.02	3.67	.001
11	Professional Development	.17	.67	.488	.238	.001	-.02	3.32	.001

'Statistical Core Model = Variables Entered at Step 5
Expanded Theoretical Model =Variables Entered at Step 8

Summary Table 5: STEPWISE MULTIPLE REGRESSION TO PREDICT COST PER PUPIL

Step	Variable Entered'	F to Enter	P Value Variable	Multiple R	R^2	R^2 Change	Simple R	Overall F	P Value Model
1	District Size	18.81	.001	.359	.129	.129	-.36	18.81	.001
2	Chapter 1 Budget	12.37	.001	.454	.207	.078	-.04	16.43	.001
3	Instructional Grouping	8.26	.005	.506	.256	.049	-.23	14.34	.001
4	Licensed Teachers	6.96	.009	.543	.296	.040	.32	13.01	.001
5	Project Setting	1.26	.26	.550	.303	.007	.20	10.68	.001
6	Supplies/Materials	.77	.38	.554	.307	.004	-.14	9.01	.001
7	Professional Development	.65	.42	.557	.311	.004	.06	7.80	.001
8	Administration	.37	.54	.559	.313	.002	.01	6.83	.001

'Statistical Core Model = Variables Entered at Step 4
Expanded Theoretical Model = Variables Entered at Step 5

APPENDIX C

CORRELATION MATRIX

CORRELATION MATRIX OF DERIVATION SAMPLE VARIABLES IN THE EXPANDED REGRESSION MODELS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1. District Size		.68	-.28	-.02	.17	.18	-.18	-.24	.31	.08	.08	-.17	.02	-.20	.45	.34	.36	.15	-.38
2. Chapter 1 Budget			-.10	-.09	.06	-.19	-.18	-.11	.16	.19	.16	-.12	.02	-.02	.01	-.03	.06	.02	-.04
3. Entering Achievement-Reading				.08	-.12	.06	.03	.05	-.04	.04	.03	-.05	-.06	.14	-.40	-.21	-.53	-.20	.09
4. Entering Achievement-Math					-.09	.05	.04	-.12	.12	.03	-.10	-.09	.09	.27	-.02	-.12	-.13	-.29	-.04
5. Supplies/Materials						.06	.05	-.02	-.01	.01	.05	.08	.02	-.09	.23	.12	.19	-.01	-.14
6. Project Setting-Reading							.95	.16	-.25	.04	-.10	.04	-.22	-.11	-.14	.01	-.05	.12	.16
7. Project Setting-Overall								.18	-.27	.04	-.12	.02	-.20	-.12	-.13	.02	-.03	.13	.20
8. Licensed Teachers									-.82	-.35	-.08	.08	-.09	-.03	-.22	-.12	-.07	.05	.32
9. Teacher Aides										-.07	-0-	-.15	.12	.04	.23	.04	.10	-.14	-.34
10. Administration											.07	.12	-.02	.03	-.13	-.03	-.13	-0-	.01
11. Professional Development												.10	-.09	-.06	.06	.11	-.12	-.02	-.06
12. Student/Teacher Ratio-Math													-.49	-.02	-.16	.14	-.15	-.07	.26
13. Instruction Group-Overall														.29	.12	.02	.10	-.07	-.23
14. Hours Math Per Year															-.29	-.26	-.34	-.25	.01
15. CE Index-Reading																.79	.76	.41	-.51
16. CE Index-Math																	.51	.74	-.44
17. Effectiveness-Reading																		.50	-.15
18. Effectiveness-Math																			-0-
19. Cost Per Pupil																			

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APPENDIX D

T-TEST TABLES

Table 1: T-TESTS OF DISTRICT SIZE' ON THE DEPENDENT MEASURES

VARIABLE	N	MEAN	SD	T-VALUE	2-TAIL PROBABILITY
COST PER PUPIL					
Small Districts	77	$655	$388	4.77	.001*
Large Districts	64	$412	$200		
NCE GAIN-READING					
Small Districts	77	6.88	5.09	-4.04	.001*
Large Districts	64	10.60	5.82		
NCE GAIN-MATH					
Small Districts	77	8.64	6.98	-2.76	.007*
Large Districts	64	11.98	7.37		
CE INDEX-READING					
Small Districts	77	.012	.011	-5.15	.001*
Large Districts	64	.029	.025		
CE INDEX-MATH					
Small Districts	77	.015	.014	-4.31	.001*
Large Districts	64	.032	.029		

' Small Districts = Below Median Enrollment
Large Districts = Above Median Enrollment

* Statistically significant at $p \leq .05$

Table 2: T-TESTS OF TEACHERS VS. AIDES ON THE DEPENDENT MEASURES

VARIABLE	N	MEAN	SD	T-VALUE	2-TAIL PROBABILITY
COST PER PUPIL					
Teachers	56	$666	$437	3.18	.002*
Aides	85	$465	$222		
NCE GAIN-READING					
Teachers	56	8.57	5.99	-0-	.99
Aides	85	8.57	5.57		
NCE GAIN-MATH					
Teachers	56	11.61	8.30	1.83	.07
Aides	85	9.20	6.48		
CE INDEX-READING					
Teachers	56	.018	.021	-.59	.55
Aides	85	.020	.020		
CE INDEX-MATH					
Teachers	56	.025	.028	1.00	.32
Aides	85	.021	.020		

* Statistically significant at $p \leq .05$

Table 3: T-TESTS OF READING PROJECT SETTING ON THE DEPENDENT MEASURES

VARIABLE	N	MEAN	SD	T-VALUE	2-TAIL PROBABILITY
COST PER PUPIL					
Pull-out	109	$575	$366	2.66	.009*
In-class	30	$442	$196		
NCE GAIN					
Pull-out	109	8.49	5.77	-.80	.43
In-class	30	9.43	5.33		
CE INDEX					
Pull-out	109	.018	.019	-1.61	.10
In-class	30	.025	.023		

* Statistically significant at $p \leq .05$

Table 4: T-TESTS OF STUDENT-TEACHER RATIO GROUPINGS IN MATH ON SELECTED MEASURES

VARIABLE	N	MEAN	SD	T-VALUE	2-TAIL PROBABILITY
COST PER PUPIL					
Groups of 2-5	75	$459	$190	-2.78	.007*
Other	59	$597	$340		
NCE GAIN					
Groups of 2-5	75	11.86	7.19	2.25	.030*
Other	59	9.09	6.74		
CE INDEX					
Groups of 2-5	75	.029	.027	3.67	.001*
Other	59	.016	.016		
HOURS PER YEAR					
Groups of 2-5	75	63	29	-1.02	.31
Other	59	69	38		

* Statistically significant at $p \leq .05$

APPENDIX E

CROSS-VALIDATION TABLES

Table 1: CROSS-VALIDATION OF THE READING COST-EFFECTIVENESS MODELS

	PREDICTED INDEX CORE MODEL	ACTUAL INDEX	PREDICTED INDEX EXPANDED MODEL
Mean	.0156	.0337	BAD DATA
SD	.0130	.0628	BAD DATA
r	.45		Uncomputable (at this time)
R^2	.20		
P	.001		

Table 2: CROSS VALIDATION OF THE MATH COST-EFFECTIVENESS MODELS

	PREDICTED INDEX CORE MODEL	ACTUAL INDEX	PREDICTED INDEX EXPANDED MODEL
Mean	.0319	.0367	.0289
SD	.0151	.0566	.0203
r	.47		.47
R^2	.22		.22
P	.001		.001

Table 3: CROSS VALIDATION OF THE READING EFFECTIVENESS MODELS

	PREDICTED NCE GAIN CORE MODEL	ACTUAL NCE GAIN	PREDICTED NCE GAIN EXPANDED MODEL
Mean	8.00	10.79	8.02
SD	3.88	8.47	3.75
r	.44		.44
R^2	.19		.19
P	.001		.001

Table 4: CROSS VALIDATION OF THE MATH EFFECTIVENESS MODELS

	PREDICTED NCE GAIN CORE MODEL	ACTUAL NCE GAIN	PREDICTED NCE GAIN EXPANDED MODEL
Mean	16.47	13.02	25.35
SD	5.66	10.27	9.41
r	.36		.17
R^2	.13		.03
P	.001		.12 (NS)

Table 5: CROSS VALIDATION OF THE COST MODELS

	PREDICTED COST PER PUPIL CORE MODEL	ACTUAL COST PER PUPIL	PREDICTED COST PER PUPIL EXPANDED MODEL
Mean	$386.94	$542.36	$399.29
SD	$585.19	$277.14	$546.48
r	.33		.34
R^2	.11		.12
P	.003		.002

Table 6: DEGREE OF R^2 SHRINKAGE IN CORE VS. EXPANDED MODELS

	R^2 Shrinkage Core Model	vs.	R^2 Shrinkage Expanded Model
Reading CE	22		Uncomputable
Math CE	5		11
Reading Effectiveness	19		21
Math Effectiveness	6		(NS)
Cost	19		18